91602
new 82-10

ontario hydro
research division
COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

SOUTH FALLS GS
EVALUATION OF THE CONDITION OF THE CONCRETE

Report No. 87-268-K

H. Caratin
Engineer
Concrete Technology Section
Civil Research Department

ABSTRACT

Samples of concrete from the intake structure and the dam at South Falls GS were obtained by core drilling, for the purpose of evaluating the condition of the concrete. The concrete in the intake structure was found to be in good to fair condition. The concrete in the dam comprises the original concrete and repair concrete. The original concrete, although of variable quality and low strength, appears to be in fair condition. The repair concrete is not properly bonded to the original concrete and contains carbonates which are susceptible to deterioration due to the acidity of the water.

job	file	date	report no.
42-144-575	842.5	November 30, 1987	87-268-K

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	PROCEDURES	1
3.0	OBSERVATIONS	2
3.1	Intake Structure	2
3.2	Dam	2
4.0	TEST RESULTS	3
5.0	CONCLUSIONS	3
5.1	Intake Structure	3
5.2	Dam	3
Appendix A		12
DISTRIBUTION		last page

91601
new 82-10

ontario hydro
research division

To Mr. J.V. Doyle
Manager
Civil Works Department
A12H18

Attn: Mr. T.W. Frost

SOUTH FALLS GS
EVALUATION OF THE CONDITION OF THE CONCRETE

H. Caratin

1.0 INTRODUCTION

In accordance with instructions received from Mr. T.W. Frost of the Civil Works Department, an investigation into the condition of the concrete in the intake structure and the dam of South Falls GS was carried out during September and November 1986.

2.0 PROCEDURES

The field portion of the investigation consisted of core drilling representative sections of the structures with a 100 mm (4 inches) nominal diameter, water cooled, diamond core bit. Drilling was performed to obtain samples of the concrete at various depths for visual examination and laboratory testing for physical properties.

Drilling operations were carried out on two occasions, September 16 and November 12, 1986.

On September 16 no de-watering was done for drilling operations. Difficulty in obtaining cores resulted in the need to re-visit the site on November 12 to drill below water level, after de-watering.

The locations selected for drilling were as follows:

1. Intake Structure - Pier 3, between sluices 2 and 3, was drilled vertically down at approximately 500 mm (20 inches) from the upstream face to a depth of 1850 mm (6 ft) and horizontally from the upstream face to a depth of 690 mm (27 inches) (Figures 1 to 3).

2. Dam - The upstream and downstream faces of Pier 4 (Figures 4 to 6), the upstream and downstream faces of Pier 3 (Figures 7 and 8) and the downstream face of Pier 1 (Figure 9) were the other locations drilled.

All piers for both intake structure and dam are numbered from left to right facing upstream.

3.0 OBSERVATIONS

3.1 Intake Structure

Almost 100% core recovery was obtained when drilling Pier 3 vertically down to a depth of 1850 mm (72 inches). At this depth, a discontinuity was encountered in the concrete and further recovery of the core was not possible. Drilling was discontinued at this depth. A core was later attempted horizontally from the upstream face at approximately the same elevation, that is 1850 mm (72 inches). Core recovery was again good to a depth of 690 mm (27 inches), but not beyond. The probable cause was that a boulder was encountered during drilling making both the drilling and the recovery difficult (Figures 1 to 3). All cores recovered indicated sound, dense concrete.

3.2 Dam

The vertical drilling of a core from Pier 4 produced one testable length of core from the top 300 mm (12 inches) of concrete. Coring progressed to a depth of 1750 mm (69 inches), but no testable cores were recovered from 300 to 1750 mm (12 to 69 inches). It was orginally suspected that the reason for the lack of recovery was due to the poor quality of the concrete. It was later determined by drilling horizontally into the pier, after de-watering, that the poor recovery was due to drilling difficulties.

Drilling of the downstream face of Pier 1 (Figure 9) indicated good concrete to a depth of 500 mm (23 inches).

Drilling of the downstream face of Pier 4 (Figure 6) indicated good concrete to a depth of 910 mm (36 inches). At this pier, 600 mm (24 inches) of core was recovered. The next 300 mm (12 inches) could not be recovered, although the drilling effort indicated that the concrete was good.

Due to the poor core recovery from the vertical drilling of Pier 4, it was decided to drill the upstream and downstream faces of Pier 3 horizontally (Figures 7 and 8). Pier 3 was selected over Pier 4 due to easier access. On the downstream face, 235 mm (9 1/4 inches) of the core was recovered. At this depth a layer of poor quality concrete (rubble), about 50 to 75 mm (2 to 3 inches) thick, was encountered. Drilling continued to a depth exceeding one-half of the width of the pier.

The concrete beyond the deteriorated layer is of good quality. The discontinuity encountered at 235 mm (9 1/4 inches) is due to the previous repair of the downstream face of the piers. Deterioration has occurred at the interface between the two concretes (old and new). Additionally, the new concrete contains carbonates which dissolve when exposed to acidic water (Figure 10).

At the upstream face, two 300 mm (12 inch) cores were recovered.

A core log is attached as Appendix A.

4.0 TEST RESULTS

Selected lengths of cores were tested for compressive strength, density and absorption in accordance with appropriate CSA or ASTM standards.

A summary of the test results is attached.

5.0 CONCLUSIONS

5.1 Intake Structure

The intake structure piers appear to be visually sound. Due to the presence of some large boulders, it was difficult to obtain testable cores; however, it is apparent from the cores recovered that the concrete is sound, of variable quality, and has a compressive strength of at least 20 MPa (3000 psi).

5.2 Dam

The main dam structure itself comprises two different concretes, the original concrete visible on the upstream portion ("old") and the encapsulating concrete ("new") visible on the downstream piers. This fact was reported previously by Civil Works*.

The original concrete could not be drilled successfully due to the presence of the large sized aggregates; however, from the tests on the cores obtained on the two attempts, it was determined that the concrete is of variable quality and has a compressive strength in the range of 14 to 17 MPa (2000 to 2500 psi).

Some deterioration was noted between the old and new concrete in Core 5. The rubble encountered between core Sections 5A and 5B could be either poor concrete that was not removed at the time of the encapsulation or the old concrete has further deteriorated at the interface of the two layers of concrete. Also, some water seepage was noted between the two concretes (Figure 11).

The "new" concrete contains carbonate aggregates which react with the acidic water and are dissolving (Figure 10). This is not a very serious condition since it only affects the outer layer of the concrete.

At several locations, the downstream encapsulation concrete is spalling and cracked, exposing the reinforcing steel. This condition, together with photographs, was documented in Civil Works Report #7381H43. Above the water

*Civil Works Inspection Report #7381H43 by T.W. Frost.

level, the encapsulation appears to be effective, as noted in Core 2 drilled adjacent to the former log chute; however, it does not appear to be durable where it is exposed to constant wetting.

The significance of the fact that the encapsulating concrete is not, in places, firmly attached to the original concrete should be evaluated from a structural viewpoint. The load from the service deck is partially transferred to the downstream faces of the piers by steel columns (Figures 8 and 11) and the stability of this arrangement is questionable.

We recommend that all loose concrete in the downstream face be removed and replaced with a concrete which is compatible and firmly bonded to the original concrete. This may not be the preferable method of repair as similar deterioration may re-occur.

Consideration should also be given to rebuilding the structure, as we suspect that removal of this repair concrete and the underlying original concrete will be extensive.

Approved by:

T.W. Klym
Manager
Civil Research Department

Prepared by:

H. Caratin
Engineer
Concrete Technology Section

Reviewed by:

G.S. Kellay
Supervising Engineer
Concrete Technology Section

HC:mao/msf

SUMMARY OF TEST RESULTS

Core #	Density kg/m^3 (lb/ft^3)	Absorption (%)	Compressive Strength MPa (psi)	Location Remarks*
1A	2420 (151.1)	5.7	40.4 (5860)	Intake
1B	2525 (157.6)	2.4	57.4 (8330)	Intake
1C	2499 (156.0)	3.9	21.0 (3040)	Intake
1D	2489 (155.4)	5.1	22.2 (3225)	Intake
1E	2420 (151.1)	9.3	18.8 (2730)	Intake
2A	2481 (154.9)	-	30.6 (4430)	Pier 4 - New
3A	2334 (145.7)	-	14.1 (2050)	Pier 4 - Old
4A	2420 (151.0)	8.6	13.7 (1985)	Pier 1 - Old
4B	2485 (155.1)	6.1	14.5 (2100)	Pier 1 - Old
5A	2469 (154.1)	-	35.8 (5190)	Pier 3 - New
5B	2422 (151.2)	-	20.0 (2900)	Pier 3 - Old
6A	2332 (145.6)	-	20.3 (2950)	Pier 3 - Old
6B	2395 (149.5)	-	16.3 (2360)	Pier 3 - Old
7A	2389 (149.1)	-	19.0 (2760)	Intake

- Not tested for absorption
*Old and New refer to original and encapsulating concrete, respectively.

Figure 1 - Overall view of the intake structure. Note large boulders in the pier. Pier 1 is on the right side of this figure.

Figure 2 - Close-up view of Pier 3. This pier was drilled vertically at approximately 500 mm from the face.

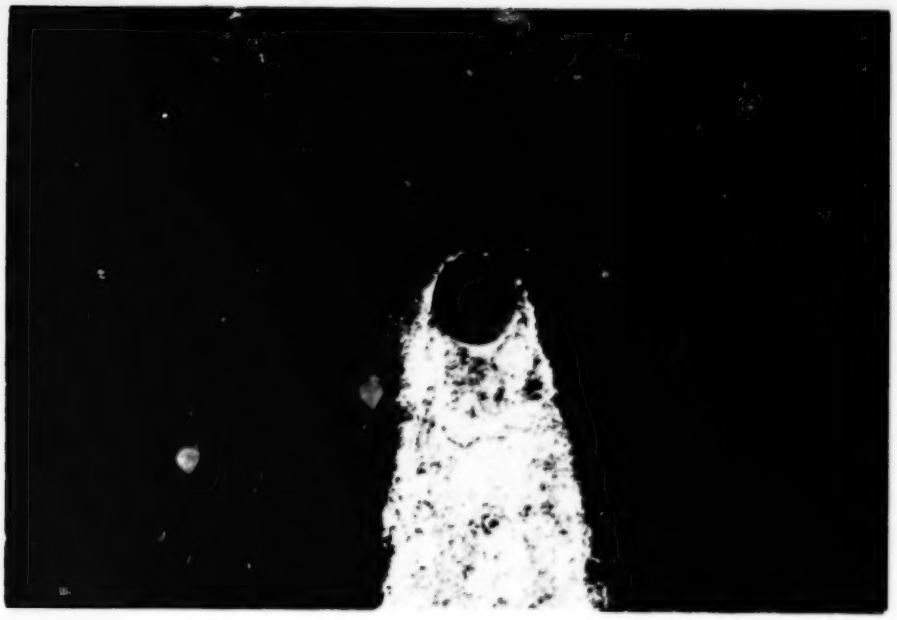

Figure 3 - Close-up of location drilled from the upstream.

Figure 4 - Drilling of Pier 4 vertically down near the upstream nose.

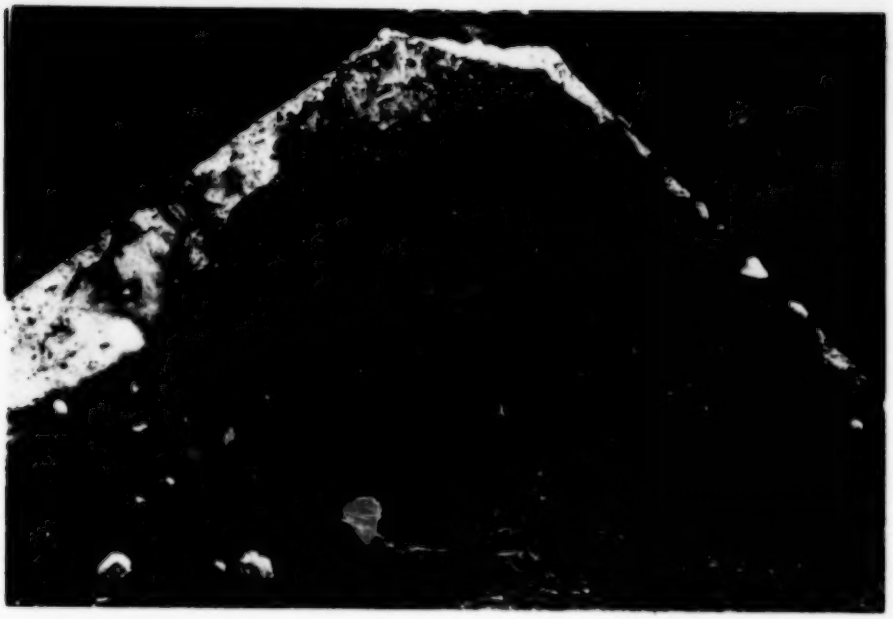

Figure 5 - Core location at Pier 4.

Figure 6 - Core location at downstream face of Pier 4.

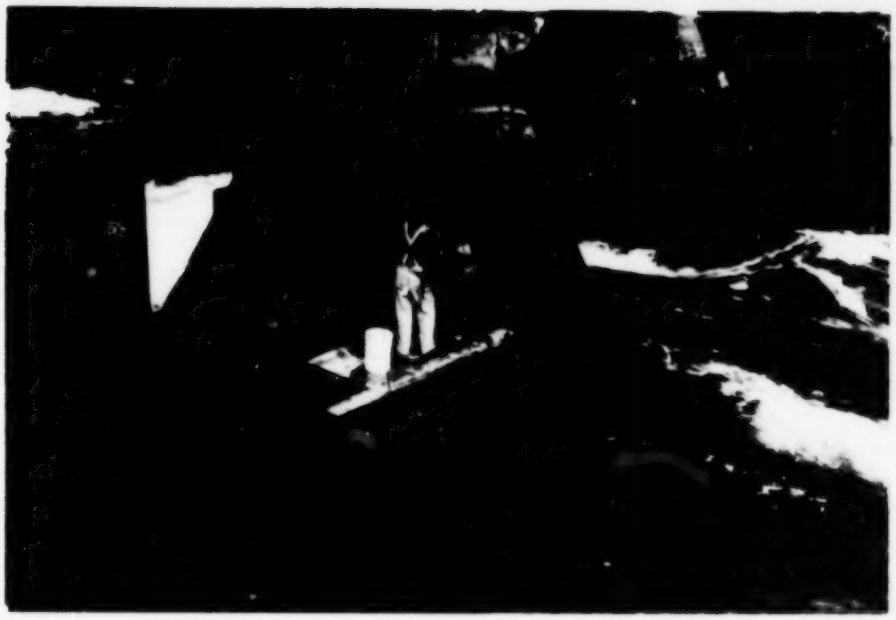

Figure 7 - Drilling at the upstream face of Pier 3.

Figure 8 - Drilling at downstream face of Pier 3.

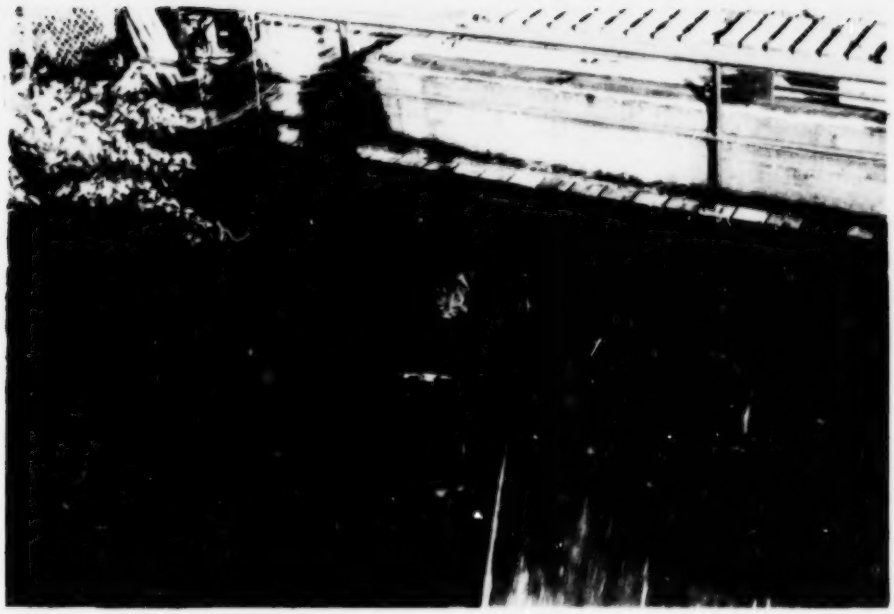

Figure 9 - Drilling at downstream face of Pier 1.

Figure 10 - Close-up of downstream face of concrete. Note deterioration of downstream face concrete compared to upstream face.

Figure 11 - Downstream face of pier. Note water exiting from concrete at arrow location.

APPENDIX A

CORE LOG

No.	Location	From - To mm (Inches)	Ident	Description
1	Intake structure Pier 3 - drilled vertically down	0-330 (0-13)	1A	Sound concrete
		330-660 (13-26)	1B	Sound concrete
		660-965 (26-38)	1C	Sound concrete
		965-1245 (38-49)	1D	Sound concrete
		1245-1550 (49-61)	1E	Sound concrete - large aggregate
		1550-1855 (61-73)	1F	Sound concrete
		1850-? (72-?)	1G	No recovery possible due to boulder in concrete-drilling discontinued
2	Downstream face of Pier 4 drilled horizontally	0-180 (0-7)	2A	Two different concretes - good bond
		180-480 (7-19)	2B	Poor concrete/large aggregates
		480-? (19-?)	2C	Core not recovered
3	Upstream face of Pier 4 - drilled vertically down approximately 600 mm (24 inches) from nose	0-300 (0-12)	3A	Fair concrete
		300-600 (12-24)	3B	Poor recovery - rubble
		600-910 (24-36)	3C	Poor recovery - rubble
		910-2130 (36-48)	3D	Poor recovery - rubble
		2130-1525 (48-60)	3E	Poor recovery - rubble
		1525-1750 (60-69)	3F	No recovery
4	Downstream face of Pier 1 - drilled horizontally	0-280 (0-11)	4A	Fair concrete
		280-585 (11-23)	4B	Fair concrete - coring stopped due to steel filling in wash water

CORE LOG

No.	Location	From - To mm (Inches)	Ident	Description
5	Downstream face of Pier 3 - drilled horizontally	0-235 (0-9 1/4)	5A	Good concrete - surface aggregate deteriorated
		235-300 (9 1/4-12)	-	Rubble, later determined to be deteriorated "old" concrete
		300-533 (12-21)	5B	Core broken at internal crack - sound concrete
		533-810 (21-32)	5C	Sound concrete - one 230 mm (9 inches) long piece of aggregate in core
6	Upstream face of Pier 3 - drilled horizontally	0-300 (0-12)	6A	Sound concrete
		300-600 (12-24)	6B	Sound concrete
7	Intake structure Pier 3 - drilled horizontally at same elevation as core 1G	0-280 (0-11)	7A	Sound concrete
		280-460 (11-18)	7B	Sound concrete - core broke at a large aggregate
		460-680 (18-27)	7C	Core broke into four pieces due to large aggregate. This is probably the reason why Core 1 could not be recovered at this depth

DISTRIBUTION

Mr. J.V. Doyle	Civil Works Department - A12-H18
Mr. T.W. Frost	Civil Works Department - A12-G18
Dr. T.W. Klym	Civil Research
Mr. G.S. Kellay	Civil Research
Mr. H. Caratin (2)	Civil Research

Public Reference Centre
Editorial Section (2)
Office Copies (2)
Extra Copies (2)